PREFABRICATED FOLDING STRUCTURE HAVING INTERLOCKING METAL BEAMS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to prefabricated folding structures, or more particularly to prefabricated residential dwellings comprised of a prefabricated floor, wall and roof members that fold inwardly upon itself to produce a compact partially collapsed folded structure, which is easily transportable, and then unfold outwardly for quick and easy on-site installation.

Description of the related art

The vast majority of structures, particularly residential houses, are completely constructed on-site. In the various sequential construction stages required materials and labor are brought to the site. A foundation is laid and the shell of the house is framed. Thereafter, exterior walls, roofing, and floors are installed using plywood sheets, followed by the installation of exterior siding and roof shingles. Windows, heating, electrical and plumbing systems are installed by heating contractors, electricians and plumbers. Insulation is added followed by installation of all the interior walls and floors. Thereafter, appliances are positioned and connected to the electrical and plumbing systems. Interior finishing work such as painting, wall-papering, and interior trim follow.

While on-site construction, is the predominant form of house construction, such entail considerable labor costs. It would be desirable to reduce construction costs by taking advantage of the economies of scale available with factory prefabricated

housing.

Prefabricated building structures are well known and the majority of these comprise pre-cast or pre-assembled panel structures which are transported to an erection site and assembled. Although many of the component parts of the buildings are pre-fabricated, the erection time can be fairly lengthy and inclement weather conditions can further slow down the erection time as well as expose building materials to the elements. Often, the pre-assembled parts are difficult to transport, heavy to manipulate and often require the use of large cranes for assembly. Prior alternatives involve prefabricating various portions of a house at a central facility or plant, transporting these portions to a building site and then performing the remaining assembly work on-site. It was believed that by prefabricating a significant portion of a house, sufficient cost savings would occur so that the purchase price of the installed prefabricated house would be less than that of a similarly sized conventionally constructed house. However, the installation cost of prefabricated prior art structures was found to be substantial and, when added to the cost of manufacture and delivery, caused the total cost of any of these prefabricated structures to exceed that of conventional construction. Many of the prefabricated or other type home or building structures are constructed for permanent installation and cannot be easily dismantled and reassembled on another site. A still further disadvantage of prefabricated structures is that often these are not very structurally sound and can become damaged if exposed to tornadoes or hurricane force winds. Some of these are also not well insulated or resistant to insect infestation such as by termites. Still further prefabricated building structures require expensive foundations made of concrete thereby increasing the cost of the prefabricated structure. U.S. 6,253,521 shows a steel-framed building construction. A number of prefabricated sections are assembled on a construction site, however, such is not foldable. U.S. 5,950,373

shows a transportable structure kit. All of the parts for a disassembled housing structure are placed in a transportable container for subsequent assembly. U.S. 6,295,766 shows a multistory, modular building structure which may be mounted on a trailer, however such is not indicated to be foldable. U.S. 5,960,593 shows a transportable and collapsible building, however, such is for temporary use as a bar, or the like, for example at sporting functions. Such is not habitable. This invention improvers on U.S. patents 4,545,171; 4,660,332 and 3,348,344, all of which are incorporated herein by reference, which show prefabricated folding structures suitable for residential housing, however, the frameworks thereof are made of hardwood materials which are subject to termite infestation and can become damaged if exposed to hurricane force winds. U.S. patent 5,890,341 shows a modular, structure, but does not mention steel framing. U.S. 6,434,895 shows a foldable, trailerable building which is useful as a field office, however, no plumbing or electrical capability is mentioned and such would not be suitable as a residential dwelling.

It has now been found that a permanent, pre-fabricated, modular, building may be formed from interlocking rooms using interlocking, pivoting metal channel beams which are resistant to insect infestation and hurricane force winds. The structure has a number of rooms having pivotably floor, roof and wall sections which fold upon one another and thereby form a compact folded structure, and which when unfolded, deploy to form a habitable structure.

SUMMARY OF THE INVENTION

The invention provides a prefabricated folding structure comprising:

a generally rectangular central core comprising a plurality of core walls, a core floor section connected to and extending between the core walls at a base of the core walls, and a core roof section connected to and over the core walls and

over the core floor section; each of said core walls, core floor section and core roof section comprising a plurality of spaced metal channel beams having at least one flat side;

a plurality of folding rooms attached to the central core; each folding room comprising a plurality of room wall members, a folding room floor section removably attached to and extending between the room walls at a base of the room walls and a folding a room roof section removably attached to and extending over the room wall members and extending over the room floor section; each of the room wall members, the room floor section and the room roof section comprising a plurality of spaced metal channel beams having at least one flat side;

at least one said room floor section being pivotedly connected at one end thereof to said core floor section; at least said one room roof section being pivotedly connected at one end thereof to said core roof section; said room wall members being removably attached to said room floor section and said room roof section; each room roof section being pivotedly connected to the core roof section on the same side of the central core as each room floor section is connected to the core floor section;

wherein each folding room floor section and each folding room roof section may be alternately detached from its room wall members and pivoted inwardly toward said central core and positioned in close proximity to and substantially parallel to a corresponding core wall and thereby form a compact folded structure, or pivoted outwardly away from said central core to define a room adjacent to said central core when attached to its room wall members.

The invention also provides a multistory prefabricated folding structure comprising:

a generally rectangular central core comprising a plurality of core walls, a core floor section connected to and extending between the core walls at a base of the core walls, and a core roof section connected to and over the core walls and over the core floor section; each of said core walls, core floor section and core roof section comprising a plurality of spaced metal channel beams having at least one flat side;

a plurality of folding rooms attached to the central core; each folding room comprising a plurality of room wall members, a folding room floor section removably attached to and extending between the room walls at a base of the room walls and a folding a room roof section removably attached to and extending over the room wall members and extending over the room floor section; each of the room wall members, the room floor section and the room roof section comprising a plurality of spaced metal channel beams having at least one flat side;

at least one said room floor section being pivotedly connected at one end thereof to said core floor section; at least said one room roof section being pivotedly connected at one end thereof to said core roof section; said room wall members being removably attached to said room floor section and said room roof section; each room roof section being pivotedly connected to the core roof section on the same side of the central core as each room floor section is connected to the core floor section;

a sub-core attached under the central core, said sub-core comprising a generally rectangular central sub-core comprising a plurality of sub-core walls, a sub-core floor section connected to and extending between the sub-core walls at a

base of the sub-core walls, each of said sub-core walls and the sub-core floor section comprising a plurality of spaced metal channel beams having at least one flat side;

a plurality of folding sub-rooms, one folding sub-room attached under one of the folding rooms and also attached to the central sub-core; each folding sub-room comprising a plurality of sub-room wall members, and a folding sub-room floor section removably attached to and extending between the sub-room walls at a base of the sub-room walls; each of the sub-room wall members and the sub-room floor section comprising a plurality of spaced metal channel beams having at least one flat side;

at least one said sub-room floor section being pivotedly connected at one end thereof to said sub-core floor section; said sub-room wall members being removably attached to said sub-room floor section;

wherein each folding room floor section and each folding room roof section may be alternately detached from its room wall members and pivoted inwardly toward said central core or central sub-core and positioned in close proximity to and substantially parallel to a corresponding core wall or sub-core wall and thereby form a compact folded structure, or pivoted outwardly away from said central core to define a room adjacent to said central core when attached to its room wall members;

wherein each folding sub-room floor section may be alternately detached from its sub-room wall members and pivoted inwardly toward said central sub-core and positioned in close proximity to and substantially parallel to a corresponding sub-core wall and thereby form a compact folded structure, or

pivoted outwardly away from said central sub-core to define a room adjacent to said central sub-core when attached to its sub-room wall members.

The invention further provides a three-story prefabricated folding structure comprising:

a generally rectangular central core comprising a plurality of core walls, a core floor section connected to and extending between the core walls at a base of the core walls, and a core roof section connected to and over the core walls and over the core floor section; each of said core walls, core floor section and core roof section comprising a plurality of spaced metal channel beams having at least one flat side;

a plurality of folding rooms attached to the central core; each folding room comprising a plurality of room wall members, a folding room floor section removably attached to and extending between the room walls at a base of the room walls and a folding a room roof section removably attached to and extending over the room wall members and extending over the room floor section; each of the room wall members, the room floor section and the room roof section comprising a plurality of spaced metal channel beams having at least one flat side;

at least one said room floor section being pivotedly connected at one end thereof to said core floor section; at least said one room roof section being pivotedly connected at one end thereof to said core roof section; said room wall members being removably attached to said room floor section and said room roof section; each room roof section being pivotedly connected to the core roof section on the same side of the central core as each room floor section is connected to the core floor section;

a sub-core attached under the central core, said sub-core comprising a generally rectangular central sub-core comprising a plurality of sub-core walls, a sub-core floor section connected to and extending between the sub-core walls at a base of the sub-core walls, each of said sub-core walls and the sub-core floor section comprising a plurality of spaced metal channel beams having at least one flat side;

a plurality of folding sub-rooms, one folding sub-room attached under one of the folding rooms and also attached to the central sub-core; each folding sub-room comprising a plurality of sub-room wall members, and a folding sub-room floor section removably attached to and extending between the sub-room walls at a base of the sub-room walls; each of the sub-room wall members and the sub-room floor section comprising a plurality of spaced metal channel beams having at least one flat side;

at least one said sub-room floor section being pivotedly connected at one end thereof to said sub-core floor section; said sub-room wall members being removably attached to said sub-room floor section;

wherein each folding room floor section and each folding room roof section may be alternately detached from its room wall members and pivoted inwardly toward said central core or central sub-core and positioned in close proximity to and substantially parallel to a corresponding core wall or sub-core wall and thereby form a compact folded structure, or pivoted outwardly away from said central core to define a room adjacent to said central core when attached to its room wall members;

wherein each folding sub-room floor section may be alternately detached from its sub-room wall members and pivoted inwardly toward said central sub-core and positioned in close proximity to and substantially parallel to a corresponding sub-core wall and thereby form a compact folded structure, or pivoted outwardly away from said central sub-core to define a room adjacent to said central sub-core when attached to its sub-room wall members;

a second sub-core attached under the sub-core, said second sub-core comprising a generally rectangular central second sub-core comprising a plurality of second sub-core walls, a second sub-core floor section connected to and extending between the second sub-core walls at a base of the second sub-core walls, each of said second sub-core walls and the second sub-core floor section comprising a plurality of spaced metal channel beams having at least one flat side;

a plurality of folding second sub-rooms, one folding second sub-room attached under one of the folding sub-rooms and also attached to the central second sub-core; each folding second sub-room comprising a plurality of second sub-room wall members, and a folding second sub-room floor section removably attached to and extending between the second sub-room walls at a base of the second sub-room walls; each of the second sub-room wall members and the second sub-room floor section comprising a plurality of spaced metal channel beams having at least one flat side;

at least one said second sub-room floor section being pivotedly connected at one end thereof to said second sub-core floor section; said second sub-room wall members being removably attached to said second sub-room floor section;

wherein each folding room floor section and each folding room roof section may be alternately detached from its room wall members and pivoted inwardly toward said central core or central sub-core and positioned in close proximity to and substantially parallel to a corresponding core wall or sub-core wall and thereby form a compact folded structure, or pivoted outwardly away from said central core to define a room adjacent to said central core when attached to its room wall members;

wherein each folding sub-room floor section may be alternately detached from its sub-room wall members and pivoted inwardly toward said central sub-core and positioned in close proximity to and substantially parallel to a corresponding sub-core wall and thereby form a compact folded structure, or pivoted outwardly away from said central sub-core to define a room adjacent to said central sub-core when attached to its sub-room wall members;

wherein each folding second sub-room floor section may be alternately detached from its second sub-room wall members and pivoted inwardly toward said central second sub-core and positioned in close proximity to and substantially parallel to a corresponding second sub-core wall and thereby form a compact folded structure, or pivoted outwardly away from said central second sub-core to define a room adjacent to said central second sub-core when attached to its second sub-room wall members.

The invention also provides a process for forming a prefabricated folding structure comprising:

I. providing a trailer which comprises a rectangular framework, which framework is disposed on at least four wheels, an upper edge of the rectangular framework comprising a channel around a periphery of the framework;

II. forming a habitable structure on the trailer by erecting a generally rectangular central core comprising a plurality of core walls, a lowermost portion of each of the core walls being positioned within the channel of the trailer framework, a core floor section connected to and extending between the core walls at a base of the core walls, and a core roof section connected to and over the core walls and over the core floor section; each of said core walls, core floor section and core roof section comprising a plurality of spaced metal channel beams having at least one flat side;

attaching a plurality of folding rooms to the central core; each folding room comprising a plurality of room wall members, a folding room floor section removably attached to and extending between the room walls at a base of the room walls and a folding a room roof section removably attached to and extending over the room wall members and extending over the room floor section; each of the room wall members, the room floor section and the room roof section comprising a plurality of spaced metal channel beams having at least one flat side;

pivotedly connecting at least one said room floor section at one end thereof to said core floor section; at least said one room roof section being pivotedly connected at one end thereof to said core roof section; said room wall members being removably attached to said room floor section and said room roof section; each room roof section being pivotedly connected to the core roof section on the same side of the central core as each room floor section is connected to the core floor section;

wherein each folding room floor section and each folding room roof section may be alternately detached from its room wall members and pivoted inwardly toward said central core and positioned in close proximity to and substantially parallel to a corresponding core wall and thereby form a compact folded structure, or pivoted outwardly away from said central core to define a room adjacent to said central core when attached to its room wall members.

Thus the invention provides sturdy, habitable low-cost prefabricated structures which are not only economical to manufacture but are also easy and inexpensive to install on-site, to thereby provide significant cost savings over a similarly sized conventionally constructed structure. All the necessary systems, such as wiring, plumbing and heating, and appliances in the structure during prefabrication.

Thus the need for heavy machinery during installation of the structure as well as the labor and effort required for installation are minimized.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the outside of the inventive prefabricated folding structure shown in a completely folded shipping configuration.

FIG. 2 is a cross-sectional view of applicant's prefabricated folding structure, depicting the pivotal movement of the folding roof sections.

FIG. 3 is a cross-sectional view of the prefabricated folding structure, depicting the pivotal movement of folding floor members.

FIG. 4 is a plan elevational view of the interior of the prefabricated folding structure, depicting the movement of exterior side walls 91, 92, 93 and 94 during erection.

FIG. 5 is an exterior perspective view of the prefabricated structure shown completely unfolded and installed on-site.

FIG. 6 is a cross-sectional view of an alternate embodiment of a single story prefabricated structure, shown completely unfolded.

FIG. 7 is a cross-sectional view of a multi (two) story prefabricated house shown completely unfolded.

Figs. 8A and 8B show beams have a generally U-shaped or C-shaped cross-section.

Fig. 9 illustrates an interlocking of rafter beams wherein adjacent beams have their edge flanges cut away and one beam rests on the other prior to bolting together.

Fig. 10 illustrates an interlocking of a stud to a beam wherein a notch is cut into a bolt edge flange, a stud is positioned within the notch and rests on the opposite bolt flange prior to the stud and beam being bolted together.

Fig. 11 illustrates a trailer having a channeled framework on which a habitable structure according to the invention may be built.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention is applicable to a wide variety of structures of different weight, size, shape and materials for a variety of diverse uses. The invention pertains to single story as well as multiple story prefabricated residential dwellings constructed from interlocking rooms.

FIG. 1 shows an exterior perspective view of a single-story prefabricated folding house constructed in accordance with the invention and folded into a shipping configuration. As shown, the house contains a generally rectangularly shaped prefabricated central core 5, of which only exterior core wall 21 is shown. Positioned substantially parallel to and alongside this core wall, are the front and rear walls and pivoting floor sections.

On the sides of the core, exterior side walls 71, 72 having corners 3, are adjacent to pivoting floor section 61 at floor joist 611. Each of these joists in the pivoting floor sections are pivotedly connected at an end, via pivots 2, to a respective one of the floor joists, e.g. joist 411, which joists together comprise the floor of the central core 5. The floor of the central core is comprised of a plurality of beams, positioned substantially perpendicular to the walls of the central core, at least one beam oriented parallel to the walls of the central core connected to each of the plurality of beams, and acceptable decking material attached to and substantially covering the beams.

Preferably, these beams are made of steel, and the decking material can be plywood or fiberboard. The preferred material comprises steel studs enclosing

polystyrene foam panels or sections, such as are available commercially from ThermaSteel Corporation of Radford, Virginia. Panels, such as 4 foot by 8 foot panels may be formed by setting steel studs in a forming jig and then filling the cavity with expanded polystyrene. The polystyrene protects the steel and greatly adds to the thermal insulation value of the structure. In a particularly advantageous embodiment, the decking comprises a subflooring of plywood or the like, followed by a final floor covering of hardwood planking, carpeting, tile or linoleum, depending upon the use for that particular section of the house.

The beams of the central core floor 41 (Fig. 2), are C-shaped or U-shaped metal joists, which are preferably steel. All the joists comprising these floor members are arranged in an approximate 16" center-to-center spacing and are staggered such that an end of each floor joist in each pivoting floor member lies adjacent to an end of a corresponding floor joist in the central core. During prefabrication, both subflooring, of illustratively 5/8" thick plywood, and final floor covering, of illustratively 1/4" hardwood planking, are attached over all the joists comprising each of these floor members with exception of an area above pivots 2 between each pivoting floor section and the core floor. Affixed atop the central core is a ceiling member upon which is positioned a plurality of prefabricated roof trusses, of which only truss 31 is shown. When a folding structure is used as a single story dwelling or the top floor of a multiple story dwelling, these trusses provide support for the folding roof which is comprised of lower folding roof sections 51 and 52 and upper folding roof sections 50 and 53. Each lower roof section is pivotedly connected at one of its ends to both an end of a respective upper folding roof section and to an end of each truss. In the shipping configuration as shown, the lower folding roof sections are pivotedly oriented downward to lie alongside the pivoting floor section, and the upper folding roof sections are pivotedly oriented downward to lie against each of the trusses. These folding roof sections

preferably comprise a plurality of rafters positioned substantially perpendicular to the walls of the core, at least one rafter positioned perpendicular to the plurality of rafters for connection thereto, a sheathing material connected to and substantially covering the rafters and moisture barrier means attached to the sheathing. The moisture barrier is preferably builder felt, and a building exterior, such aluminum siding, PVC siding, shingles, cedar shakes, bricks, etc., is placed upon the moisture barrier and sheathing materials. Since the weight of the folding structure is primarily supported by the walls of the central core, relatively little weight is borne by any of the wall, and pivoting floor and pivoting roof members. Consequently, these pivoting members can be made light in weight. Not only does this advantageously eliminate the need to use a reinforced foundation, but, in addition, this advantageously minimizes the effort required to pivotally move these members into proper position during installation of the structure. Thus, once the structure is properly positioned on its foundation, only a minimum amount of labor and no heavy machinery is needed to unfold the structure and complete the installation. These factors, coupled with the use of only inexpensive standard building materials and extensive prefabrication, advantageously permit substantial cost savings to be achieved over the cost of both prior art prefabricated structures and conventional construction. The use of pivoting floor, pivoting roof and movable walls, which fold and unfold, reduces the height and width of the folded home to specifically 11 feet 4 inches and 13 feet 8 inches, respectively. Advantageously, this greatly lowers the center of gravity of the folded home. Consequently, this ensures that the house is not susceptible to being tipped over during shipment. Hence, the house can be easily and safely transported on a flatbed truck to a suitable building site. In a preferred embodiment of the invention, the entire building is constructed on a wheeled trailer, which is may be used to drive the partially built structure from assembly station to assembly station, and ultimately to the final installation site.

Once a suitable site has been appropriately excavated, a concrete foundation is laid. This foundation is provided with four points for supporting the folding structure. Two supports are located just below and outside of the core walls, and each of the two other supports is located under one of the pivoting floor sections. Thus, the two supports for the core hold the weight of the structure while the pivoting floor supports maintain the floor in the correct orientation and position i.e., parallel to and level with the core floor. A plate (not shown), which may be comprised of a pair of studs laid one atop another, is affixed all around the top surface of this foundation. These studs and the foundation are configured and arranged so as to facilitate the unfolding of the structure. Preferably, the core walls each comprise a plurality of steel studs and at least two plate members connected respectively to the top and bottom of the plurality of studs. Since these core walls are located within the folded structure, they are provided with gypsum board after the necessary piping, plumbing, and electrical components have been installed. An advantageous stud is a steel, although aluminum, or other metals could be used, if desired. Thereafter, the folded house shown in FIG. 1 is positioned on top of the plate and unfolded in a manner discussed below.

FIG. 2 depicts a cross-sectional view of the prefabricated folding house of FIG. 1. FIGS. 1 and 2 show that the folding house is comprised of a rectangularly shaped central core 5, a plurality of detachable and movable exterior wall members 71 and 72, pivoting floor sections 61 and 62; folding upper and lower roof section 50 and 53, and 51 and 52, respectively; and pivoting ceiling members 81 and 82, a plurality of prefabricated roof trusses of which only truss 31 is shown and ridge beam 56. Central core 5 is comprised of interior core walls 22, 23, 24, 26, 27 and 28, movable and detachable side walls 91, 92, 93 and 94, and exterior core walls 21 and 25 all secured, both core floor 41 and ceiling member 40 as shown in Figs.

2, 3 and 4. The central core is completely prefabricated and contains all piping, plumbing, and electrical control means (i.e.--circuit breaker box, etc.) for connection to external sources of supply (i.e. water, gas, electricity, etc.). Also, all necessary systems for the entire structure, e.g. heating, plumbing and electrical, and all the required appliances and plumbing fixtures are installed in the central core during prefabrication. Furthermore, any outlets that are to be located in any of the pivoting members, particularly the walls, are installed while the structure is being prefabricated.

As shown in FIG. 4, the core contains the kitchen including all its appliances; the bathroom--including the necessary plumbing fixtures, including a bathroom sink, tub/shower and toilet; and a closet with folding doors containing the hot water heater, washer and dryer. Each pivoting exterior wall (front wall 71, rear wall 72 and side walls 91, 92, 93 and 94) is completely assembled during pre-fabrication. These walls would be constructed in the same manner as the core walls. One difference, however, is that these walls would each have one side facing the exterior of the building. These faces would then be covered with a sheathing, moisture barrier, and finally, the desired exterior facade.

Each wall is specifically fabricated from steel studs which are approximately spaced 16" apart on a center-to-center basis. During prefabrication, windows are installed at predetermined locations into these walls, and the exterior surface of each folding wall, i.e., that surface which faces the outside environment, is covered with standard 1/2" plywood sheathing material over which a moisture barrier along with the desired siding material, e.g. aluminum siding, PVC siding, asbestos shingle or other siding material, is applied. In addition, electrical outlet boxes are affixed to various studs in these walls and wired at the factory. To conform with standard building codes, all electrical wiring is placed inside each

wall. Thereafter, thermal insulation is installed within each wall and illustratively 1/2" gypsum board, (also known as "dry wall" or "sheet rock") is then installed over the interior surface of each folding exterior wall, with an appropriately located prewired electrical outlet. If polystyrene embedded steel panels are used, such extra insulation may be eliminated. Roof and ceiling supporting structures are provided above the central core. These are located on and are supported by the common walls of the core, and preferably comprise a plurality of prefabricated steel truss assemblies. Each of the prefabricated trusses provide the necessary structural support for the upper and lower folding roof sections whenever they are pivoted into an open, i.e. unfolded, position. While only one truss 31 is shown in the cross-sectional view of FIG. 2, the house is illustratively comprised of a number of separate trusses, each fabricated from rafters and mounted on a 24" center to center spacing. Any number of trusses can be used, with the particular number being predicated upon the desired spacing between trusses and the size of the structure. The spacing for the trusses (and also for the floor joists, wall studs and ceiling rafters) is often specified by local building codes and/or practice and can thus vary from that specified below. Each truss is pivotedly attached to upper roof sections 50 and 53, and lower roof sections 51 and 52 of the roof. As shown in FIGS. 2 and 4, a number of structural members, including exterior side and front and rear walls and a pivoting floor member, are positioned during prefabrication substantially parallel to and alongside the interior core walls. These structural members are arranged in two groups of similar members, group 7 being adjacent to interior wall 28 and the other, group 8, being adjacent to interior wall 22. In the shipping configuration shown in FIG. 1, the structural members comprising each group are positioned alongside each other and are all substantially parallel to the adjacent interior core wall 22 or 28. Group 7 is comprised of free-standing partition 105, exterior side wall 91, exterior front wall 71 and pivoting floor section 61, and also, as is apparent from FIG. 4, walls 102-

104 and exterior side wall 94. Group 8 is comprised of similar structural members and free-standing partitions, specifically, exterior side walls 92 and 93, exterior rear wall 72, pivoting floor section 62, interior walls 108-112 and free standing partitions 106 and 107. It should be noted that interior walls are joined together, but are provided with an open area in between for access (i.e., a doorway). The same applies to wall 103 and 104; 108 and 110; and 109 and 111.

In accordance with this feature of the invention, substantial closet space is incorporated into the folding structure through the use of the folding interior walls and free-standing partitions. When the structure is fully folded, these interior walls and partitions are initially positioned to lie alongside various interior side walls comprising the central core. Once the walls and floor members are pivoted into their properly installed positions, an enclosed area is defined around the core. Each pivoting interior wall and each free-standing partition are then pivoted or moved to a pre-determined position within this area in order to define all the rooms arranged about the core and all the closets existing therein.

Folding the Structure

The shipping configuration, shown in FIG. 1, is achieved during prefabrication by removing the interior walls and positioning the free-standing partitions against the core walls and positioning the various structural members inwardly about the central core.

First, free-standing partition 105 is positioned, alongside interior side core wall 28. This partition is preferably oriented such that its vertical edges are parallel to those of the interior core wall. In a similar fashion, interior walls 101-104 are positioned, as shown in FIG. 4, such that each lie alongside interior side core walls 26 and 27.

Thereafter, folding ceiling members 81 and 82 are each pivotedly positioned upwardly, as shown in FIG. 2, such that each folding ceiling member, e.g. ceiling member 81, lies partially within and parallel to a corresponding lower folding roof member, e.g. folding roof member 51. The rafters in each folding ceiling member are staggered with respect to those in each corresponding lower folding roof member such that when those ceiling members are folded their joints partially interleave with those in each corresponding lower roof folding section.

Next, as shown in FIG. 4, exterior side walls 91 and 94 are positioned inwardly, about corners 4, such that these walls lie alongside free-standing partitions 105 and wall 101, respectively. Then, exterior front wall 71 is positioned downward, such that it lies alongside pivoting floor section 61.

Thereafter, pivoting floor section 61 is pivoted upward about pivot 2 located in the left end of core floor 41, such that exterior front wall 71, particularly its exterior surface, lies alongside exterior side wall 91 (and 94 not shown). Now, with all the exterior walls positioned inwardly about the core, upper folding roof section 50 and 53 are folded, as shown in FIG. 2, by being pivotedly positioned downward until each abuts against all the trusses, e.g. truss 31. Lower folding roof sections 51 and 52 are then folded by being pivotedly positioned downward and inwardly such that each lies vertically alongside folded floor members 61 and 62, respectively. The pivots 2 between folding floor members 61 and 62 and core floor 41provides a for rotation of the pivoting floor section with respect to the central core floor, means for transferring the load from the pivoting floor section to the central core floor and provides a means for reducing frictional forces during rotation of the pivoting floor section. The pivoting means is preferably bolting means or the like. Specifically, this pivoting assembly may be a 1/2" ASTM A307

bolt secured by washers and a nut. Similar pivots are between folding roof sections 51 and 52 and core 5.

Unfolding the Structure

Having summarily described the sequence in which the walls are positioned, and the folding floor and roof members fold inwardly about the central core to form the folded structure shown in FIGS. 1-3, an explanation will now be given as to the manner in which the structural members are sequentially unfolded and interlocked to transform the house from its shipping, i.e., folded, configuration into a fully habitable residential dwelling as shown in Fig. 5.

The first structural members to be unfolded are the roof sections. As shown in FIG. 2, upper folding roof sections 50 and 53 are pivotedly positioned upward and outward. Ridge beam 56 is preferably a steel beam which runs the entire length of upper folding roof section 53 and abuts against the top edge of folding roof section 50 when both these roof sections are completely unfolded. The rafters that comprise each of these upper roof sections are steel beams located on a 24" center-to-center spacing, and all the rafters comprising either of the upper roof sections are staggered with respect to those of the other. Once these upper roof sections are completely unfolded into position as shown in FIG. 2, the ridge beam and each rafter comprising folding roof sections 50 and 53 are secured sections in position. It should be noted that all upper roof sections have been fully sheathed and shingled during prefabrication. Next, as shown in FIG. 2, lower roof sections 51 and 52, each comprised of illustratively steel rafters are pivoted upward and outward into position. These rafters are connected by pivots comprising bolts. Each pivot connecting both the upper and lower roof sections to the trusses, is comprised of a series of 1/2" bolts (not shown), each of which runs through a rafter in a lower roof section, an adjacent truss and an adjacent rafter in upper roof

section. A temporary support (not shown) is then positioned under the lower end of each of these lower folding roof sections and is adjusted to an appropriate height to temporarily keep each lower roof section in its completely unfolded position. To secure the roof sections in a final position, a properly sized nut which has been threaded onto the end of each bolt is fully tightened. Again all lower roof sections have been fully sheathed and shingled during prefabrication. Once the roof is completely unfolded, folding floor member 61 and 62 are pivoted into position. Specifically, both folding floor members are pivoted downward and away from the central core, thereby forming the entire floor for the dwelling. Thereafter, as shown in FIG. 8, exterior front and rear walls 71 and 72 are set into position. Specifically, each wall is positioned outward until the upper ends of exterior front wall 71 and exterior rear wall 72 abut against all the rafters comprising lower folding roof sections 51 and 52, respectively. With these exterior front and rear walls secured in place, exterior side walls 91, 92, 93, and 94, as shown in FIG. 4, are then positioned and secured in place. Specifically, each exterior wall is positioned such that each end wall lies substantially perpendicular to the exterior front or rear walls. Once each exterior side wall is properly positioned, they are bolted to adjacent ceiling rafters and floor joists. At the end walls of the house, the ceiling and lower roof section are pivotally joined. The pivots utilized for this connection comprises means for rotation of the ceiling member with respect to the roof member, and for attaching the ceiling and roof member to the outer wall member. At this juncture, folding ceiling members 81 and 82 are unfolded into position. To accomplish this, folding ceiling members are pivoted downward such that unfolded ceiling member 81 lies on top of unfolded exterior front wall 71 and side walls 91 and 94; and unfolded ceiling member 82 lies on top of exterior front wall 72 and side walls 92 and 93, respectively. Next, exterior front wall 71 is secured to unfolded ceiling member 81 and to lower folding roof section 51. To further secure the exterior front wall

to the lower roof section, a bolt and nut assembly (not shown) preferably 1/2" diameter, which has been inserted through a pre-drilled hole and into a corresponding hole in the adjacent lower roof rafter during prefabrication, is tightened. Appropriate size washers may be used with each bolt. Exterior rear wall 72 is secured to lower folding roof section 52 in a substantially identical fashion. Since adequate support for the lower roof members is now provided by all the exterior walls, temporary supports, such as jacks that support these lower roof sections are now removed.

Once the folding ceiling members have been fully unfolded and secured in position, an enclosed area is defined about this central core. Then, interior walls 101-104 and 108-112, and free-standing partitions 105, 106, and 107, are moved into respective positions in this area to define both the rooms arranged about the central core and all the closets contained therein. Specifically, interior walls 103 and 112 are positioned in the same manner as does exterior side wall 92. Once the interior walls are positioned, then each free-standing partition is appropriately positioned in place. The interior walls and partitions are completely framed and covered with gypsum board during prefabrication. Once in position, each of these interior walls and partitions are secured by bolts, nuts and washers to the floor joists in pivoting floor sections 61 or 2, and to the rafters in ceiling members 81 and 82. Specifically these bolts are driven through adjacent rafters in the ceiling and between joists in the folding floor members, and into the top (and bottom) horizontal studs comprising each of these interior walls and partitions. Advantageously, the use of free-standing partitions, which are positioned during on-site installation, to define room sizes and closets, readily permits changing the dimensions of these rooms and closets at any time up to installation without incurring much, if any, expense. While the doors to each of the closets formed by the free-standing partitions, as well as a number of interior room doors, have all

been omitted for the sake of clarity from the plan views shown in the drawing, these doors are attached, i.e. pre-hung, to corresponding pivotal walls or free-standing partitions and interior core walls during prefabrication. Advantageously, this further reduces on-site installation time and expense.

As should be readily apparent, applicant's folding prefabricated house is now completely unfolded. At this stage of installation, the only portion of the dwelling that remains to be enclosed is the attic. To accomplish this, a prefabricated gable end is fixed to the outermost roof rafters and ceiling beams existing at each side of the dwelling. Specifically, each of the two gable ends, of which only gable end 97 is shown in FIG. 5, is triangularly shaped and is comprised of a series of steel studs (not shown) of appropriate length and mounted apart from each other on an approximate 16" center to center spacing. A layer of sheathing (not shown), preferably 1/2" plywood, is installed over these studs during prefabrication at the factory. After the gable ends are installed on-site, appropriate siding material, e.g. aluminum or shingle, is applied to the entire side of the house including the gable ends. Applying this type of siding in the field advantageously minimizes the likelihood that any misalignment between the siding on the gable ends and that on the rest of the exterior side walls will be visible. If, however, cedar shingles are used for siding, then any minor misalignment between the siding attached to the gable ends and that attached to the rest of the exterior side walls is generally not visible. Consequently, this siding material can be applied during prefabrication to both the gable ends and to all the exterior side walls in order to further reduce on-site installation time and cost. The prefabricated gable ends, are temporarily stored in the central core (more specifically by being placed on the floor of the core) while the folded house is being shipped to the building site.

The last remaining stage of installation, namely interior finishing, can now

proceed. Specifically, the edges of any interior surfaces of abutting structural members are appropriately taped, spackled and sanded, in preparation for applying final wall covering, e.g. paint, or wallpaper. Thereafter, subflooring and final hardwood planking or other final flooring materials are installed in the previously unfloored areas of the house, i.e. above pivots 4. Alternatively, the entire sub-floors and final floor covering can be installed on-site. While this latter approach slightly increases installation cost, it may be necessary, depending upon the final floor covering chosen by the owner, in order to eliminate any visible gaps or joint lines from appearing in the floor. Thereafter, molding and any remaining interior trim is now installed. At this point, the dwelling has been completely constructed and only requires connection to the local utilities, e.g. electricity and sewerage, for it to be completely habitable. An exterior perspective view of the dwelling as it stands completely installed and ready for occupancy is shown in FIG. 5.

In the illustrative embodiment described herein, heat is provided through electric baseboard. While electric heat is usually relatively expensive to operate, it is the least expensive to install. Consequently, separate electric baseboard units are installed along the interior bottom edge of various interior core walls and various folding walls. However, to minimize heating costs, a separate thermostat is installed in each room during prefabrication. Other types of heating, ventilating, and air conditioning systems, where desired, can be substituted for electric baseboard or added in addition thereto. Any desired system can be substantially shop installed during prefabrication. In addition, the necessary cable or wiring requirements (i.e., electrical, telephone, television, etc.) can be shop installed during prefabrication. Since the weight of a residential dwelling constructed in accordance with the teachings of the present invention is primarily supported by the walls comprising the central core, this advantageously permits all the pivoting

structural members to be made relatively light. Consequently, this permits each member to be pivoted into position by a few workers without using any heavy machinery. Furthermore, the minimal weight inherent in the structure eliminates the need to incorporate any columns into the structure or to construct the foundation from reinforced concrete. Consequently, these factors advantageously reduce installation cost.

The exterior front walls are not limited to being co-planar when fully unfolded. The two walls making up the exterior front wall can be staggered to create a relatively large living room, and also lend a pleasing appearance to the front of the dwelling. In a similar fashion, any of the other walls and/or core walls are also not constrained to entirely lie in a single plane but can instead by comprised of a number of staggered or otherwise non-co-planar sections. Moreover, the pivoting floor and/or ceiling member can also take on many varied non-co-planar geometries to create many diverse and architecturally pleasing layouts. Consequently, a variety of differently shaped structures, including but by no means limited to a simple rectangular layout, can be easily fabricated using the principles of the invention.

FIG. 6 illustrates a single story structure which can be provided with a flat roof or used as the first or lower floors of a multi-story structure. The single story structure or the lower floors of the multi-story structure are not provided with folding roofs or roof trusses, but instead have ceiling members 40a only in the area of the central core. Then, when such structure is to be used as a single story house, ceiling members 81a, 82a for the rooms adjacent to the central core are installed.

These members 81a, 82a shown in phantom in FIG. 6 may be pivotally connected

to ceiling members 40a in the same manner as the pivoting floor sections are connected to the core floor. Alternately, these ceiling members 81a, 82a may be field installed. In either embodiment, these ceiling members are partially supported at their opposite end by a pivotable wall member. Then, a flat or conventional roof can be constructed upon these ceiling members 40a, 81a, 82a to complete the single story structure. For multi-story, construction, the lower structures are not provided with such ceiling members 81a, 82a, since the floors of the adjacent upper structure 61, 62 become the ceiling members for the lower structure. For multi-story fabrication, it is advantageous to use steel beams 40a positioned upon the central core and to stagger the position of these beams with respect to the position of the floor joists 40 of the upper structure. Also, these beams extend slightly beyond the width of the central core 5 so as to provide enough area to pivotally connect the folding side and internal wall members. In this construction, the floor joists 40 of the upper structure will be positioned between the steel beams 40a of the lower structure. Also, the core walls, 22, 28 are sufficiently sized to support the weight of the upper structure. Then, as mentioned above, the floor members 61, 62 of the upper structure become the ceiling members of the lower structure.

Specifically, to construct a two-story residential dwelling as shown in FIG. 7, two folding structures--an upper and a lower of the type described previously, are stacked on top of each other. The main difference between these structures is that the lower structure does not contain a roof and appears substantially as shown in FIG. 6. At the time of on-site installation, the lower structure is first appropriately positioned on the foundation, and is then completely unfolded. All the folding structural members of the lower structure are then secured in position. As shown in FIG. 6, the lower folding structure is provided with 2" x 10" ceiling beams 40a straddling the central core. As mentioned above these 2" x 10" beams are

positioned in a staggered configuration such that they would not be directly under the floor joists of the upper structure. Then, the upper structure, in a completely folded position, is placed above the lower structure and the floor joists of the upper structure are supported by the walls of central core of the lower structure. In this arrangement, the floor joists of the upper structure 61, 62 become the ceiling rafters of the lower structure. All the ceiling beams 40a of the lower structure thus abut against and are attached to the central core floor joists using appropriately sized nailing plates and nails. The remaining folding structural members of the upper structure are unfolded into position and secured as described hereinabove.

Appropriate openings are provided both in the ceiling of the central core of the lower structure and in the core floor member of the upper structure during their prefabrication in order to accommodate a stair case, which can be installed in the lower structure during its prefabrication. Any necessary banisters and the like are installed during the final interior finishing stage of on-site installation. Unless the two-story dwelling is to be a two family-house, there is little if any need to include any appliances and/or a hot water heater in the upper structure. Thus, the area reserved for the kitchen and closet in the central core can be converted into other usable space, e.g. a den or study. The technique of this invention may be used to form a single family home, a town home, a two story colonial style dwelling, among others.

As can be readily appreciated by those skilled in the art, multi-story structures in excess of two stories, such as three stories can be easily constructed in a similar manner to that described above. The number of separate folding structures that can be stacked to form the multi-story structure is essentially determined by the weight of each folding structure, and the amount of weight that can be supported

by both the foundation and the walls in each folding structure, particularly the lowest in the stack.

The beams and studs used herein are metal channel beams, preferably steel channel beams having at least one flat side. The beams have a generally U-shaped cross-section with a wide flat side 150 extending to opposite perpendicular edges 152 as shown in Fig. 8A, or C-shaped cross-section with a wide flat side extending to opposite perpendicular edges having perpendicularly inwardly positioned edge flanges 154 as shown in Fig. 8B. Widths may range from about 6 inches to about 12 inches. Edges may have a height of from about 1 3/8 inch to about 3 ½ inches. Edge flanges may range from 0 to 1 inch. Typical material thickness ranges from 18 gauge to 12 gauge, i.e. from about 0.046 inch to about 0.117 inch (about 1.184 mm to about 2.982 mm). Such may be made from galvanized or carbon steel coil or sheets using a Knudson Model KR-612H, available from Knudson Manufacturing, Inc of Broomfield, Colorado. In an important embodiment of the invention, the beams and studs of the structure are connected by interlocking them together such as by fitting one beam or stud into a notch in an adjacent beam. Fig. 9 illustrates an interlocking of rafter beams wherein adjacent beams 156, 158 have their edge flanges cut away and one beam rests on the other prior to bolting together. Fig. 10 illustrates an interlocking of a stud 160 to a beam 162 wherein a notch 164 is cut into an edge flange, a stud 160 is positioned within the notch 164 and rests on the opposite flange prior to the stud and beam being bolted together. In another preferred embodiment, the bolts, especially the bolts which act as pivots are locked into the structural members which they connect by being surrounded by self-tapping screws.

While the pivoting structural members, i.e. the walls, floors, ceiling and roof members, have been described above as folding and unfolding in a particular

sequence, it is readily apparent to those skilled in the art that any or all of these structural members can be readily folded and unfolded in a variety of different sequences. The particular sequence is determined by the desired volume of the folded structure and the particular materials used for the folding members and manner in which these members are constructed.

Fig. 11 shows a trailer 202 on which the habitable structure of the invention may be built. The trailer comprises a rectangular framework 204 which is on at least four wheels. An upper edge of the rectangular framework comprising a channel 206 around a periphery of the framework. A habitable structure may be formed on the trailer by erecting a generally rectangular central core section of the previously described building within the channel 206. A lowermost portion of each of the core walls is positioned within the channel 206 of the trailer framework 204. The core is then erected on the trailer framework within channel 206 and then the folding rooms are added. This technique allows movement of the partially erected building structure from work station to work station within a suitable factory and then allows hauling of the finished structure to the final destination site, at which point it is lifted out of the trailer.

While the present invention has been particularly shown and described with reference to preferred embodiments, it will be readily appreciated by those of ordinary skill in the art that various changes and modifications may be made without departing from the spirit and scope of the invention. It is intended that the claims be interpreted to cover the disclosed embodiment, those alternatives which have been discussed above and all equivalents thereto.